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ANNEXES TO IPRP

the paper tension is reduced with respect to the paper tension as exerted by the drive system of the printer. A slanted friction roller ensures the forced contact to the single aligning edge. It was found that such a solution is not appropriate in printing systems that need to address a broad range of printing media including high gloss substrates of high weight per unit area. Forcible alignment by such a slanted roller is especially questionable as a solution when the print media have a width exceeding 250 mm. Localised friction contacts are found to damage the medium surface by locally degrading the gloss, especially for higher medium weights that require higher forces for assuring forcible contact to the single side-guide.

There remains a need for an alignment system for continuous media with reduced webwalk and which is convenient and economical.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an alignment method for use with a printer or other device and an alignment system attached to or integrated in such a printer or other device, which solves some of the above problems, especially to provide an economic alignment method and apparatus which reduces web-walking.

In one aspect the present invention provides a web alignment device to align a web of continuous print medium having two outer edges and originating from an upstream device to a stable lateral position with respect to a printing system for further printing on said continuous web, the printing system having a friction drive downstream of the web alignment device, the alignment device being

a) an alignment system to provide a stable medium path with reduced web-walk,

b) an alignment system that is not sensitive to the mechanical alignment of an upstream device such as a roll unwinder,

c) an alignment system having a lower complexity and lower cost than active controlled systems, and

d) an alignment system that is compatible with a wide range of media, ranging from lightweight papers (for example 60 gsm) to heavyweight stock (such as 300 gsm) including high weight high gloss coated grades.

The aforementioned objects are achieved by the present invention, which in an embodiment, provides a web alignment device to align a web of continuous print medium or other medium having two outer edges and originating from an upstream device to a

stable lateral position with respect to a printing system for further printing on said continuous web or with respect to another system which performs operations on a web and the printing or other system having a friction drive downstream of the web alignment device. The web alignment device can be attached to or integrated into a printer. The

the claims are used for descriptive purposes and not necessarily for describing relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other orientations than described or illustrated herein.

Figs 1a and b show schematic diagrams with a web path in a web alignment system **1** according to an embodiment of the present invention. The web alignment system in all embodiments is preferably a passive alignment system, that is it does not need to include a proximity sensor to determine the lateral position of the web and an actuator to change this location based on an error signal from the proximity sensor. A drive system 7,8 of a system which performs operations on a continuous, flexible web of material, e.g. a web based printing system, exerts a pulling tension on the web 9 in a range appropriate for the relevant process, e.g. a printing process. The drive system optionally includes a friction roller system **7** and accompanying motorized drive system **8**. Such web based systems, for example printing systems, such as described in US 5455668, can work with a combination of driven rolls operated in speed controlled mode and torque controlled mode. In printing systems a tension force per unit of medium width ranging from 100 N/m to 1000 N/m is typically imposed on the web 9 as can be measured at the input of the print engine 10.

In embodiments of the present invention a brake system **6** is used to reduce the tension force per unit of medium width preferably by a factor of at least 3, more preferable a factor of 10 when the tension in web 9 as developed by the drive system 7, 8 and the tension in the web 9 in the alignment device 1. Preferably the entry position defining means comprises one or more friction inducing rollers or fixed shaft that increase the paper tension in the alignment section above a minimum tension of 6 N/m. Whereas the paper tension force in the print system depends on the specifics of the print system that are unrelated to the present invention, it has been observed that a tension force per unit of medium width at the exit of the alignment device **1** of between 6 N/m and 50 N/m is preferable in the alignment area upstream of the brake **6**.

Brake systems **6**, can comprise any suitable braking device such as a friction brake, an electromagnetic or a vacuum brake, for instance as proposed in US685471. For example, simple friction pads that are pressed at a position where the web is supported from the opposite side by a drum which can be supported on bearings for rotation, generally provide a low cost means to impose the required tangential braking force by friction. The friction pads may be biased against the web material 9, e.g. by suitably

dimensioned springs. Materials for the friction pads can be selected from a wide range of available felt materials such as wool and its felt density etc. can be selected to maximize

Medium weight	Min R	Max R	More preferred Min R	More preferred Max R
80 gsm	6,4 mm	**300 mm**	12.8 mm	**200 mm**
300 gsm	**24 mm**	400 mm	**48 mm**	300 mm
400 gsm	32 mm	500 mm	64 mm	400 mm

Independent of weight	24 mm	300 mm	48 mm	200 mm

The means for defining the curved or partially curved first movement trajectory comprises one or more fixed rollers or curved shells that contact the web over at least part of its width, wherein at least one of these fixed rollers or fixed shells has a radius of curvature exceeding 32 mm. A suitable radius for general working has been found to be 40 mm which is a compromise of the above values. It has been found that the combined action of pulling the web in a curved paper path over one or more fixed or backward rotating surfaces, preferably of a fixed roller or curved shell, with lateral guiding on both sides followed by the increased pull after the brake **6** has an unexpectedly dramatic effect on the positional stability of the web as measured with an positional edge sensor **10** just after a drive roller.

It was moreover found that good results with web drift fluctuations being reduced to values of less than 50 microns could be maintained for a range of media when the distance between side guides 4 and 5 where adjusted to a value W as indicated in Fig 3 which is not greater than the media width (P) + 1 mm and not less than the medium width (P) – 2 mm, while it was found that for lower medium weight print media it was preferred that the value W would be set smaller than the medium width by 0,5 to 1 mm.

It was moreover found that the presence of the two side guides solves issues that can originate from print medium reels that are slightly irregularly wound. Such reels have a tendency to drift in one lateral direction as can be verified by mounting the reel upside-down – reversing the direction of walk. Systems with a single side guide would have to provide sufficient margin in the lateral force to overcome this tendency.

A surprising finding is that after selection of the proposed range for the radius of curvature of the curved shell or fixed rollers **3** and the length of the contact area, the balance between reaction forces at the side guides and forces needed for minor adjustments of the print medium sliding on the fixed surfaces were stable over a remarkably large range of print media in terms of medium weight and medium stiffness.

It should be noted that the optional integration of end segments with the adjustable side guides is not a requirement of the present invention. Moreover it was found that additional flexing of the media, by for instance an adjustable bar 11 that extends over a substantial part of the print medium width as shown in Fig 5 as part of the entry means 2 .

WHAT IS CLAIMED

1) A web alignment device (1) to align a web (9) of continuous print medium having two outer edges and originating from an upstream device to a stable lateral position with respect to a printing system for further printing on said continuous web (9), the printing system having a drive system (7,8) downstream of the web alignment device (1), the alignment device (1) comprising:

- Mechanical means (2) for defining an entry position of a web (9), the web (9) contacting the mechanical means (2) in sliding or rolling, the web (9) being supplied as a nearly tension free loop,
- Braking means (6) to reduce the tension-force per unit of medium width at the end of an alignment zone compared to the tension force per unit of medium width downstream as exerted by the drive system (7, 8) of the printing system,
- Means defining a curved or partially curved first web movement trajectory including areas where the print medium slides in friction contact with a curved surface, the means for defining the curved or partially curved first web movement trajectory being located upstream of said braking means (6), the sliding zone of the curved or partially curved first web movement trajectory extending over a finite length L1 satisfying the relation

  $$L1 > \max(50\text{ mm}, P/4)$$

  where P corresponds to the width of the print medium,
- Adjustable lateral guiding means with side guides (4, 4', 5, 5') on both side edges of the web (9) adjustable in width to contact at either of the two outer edges or at both outer edges of said print medium, thus limiting the lateral movement dimension available for said print medium in two opposing directions, the adjustable guiding means extending over a finite second web movement trajectory of said print medium, wherein the finite second web movement trajectory with side guides (4, 4', 5, 5') on both side edges of the web (9) extends in the upstream direction to further than said means (2) for defining the entry position and comprises at least a part of the first trajectory where said print medium is in sliding contact with said means defining said curved or partially curved first trajectory, L2 being the length of simultaneous side-guiding and support for sliding satisfying the relationship:

$$L2 > 2/3 * \max (50 \text{ mm}, P/4).$$

2) The device (1) of claim 1, wherein the braking means (6) is adapted to reduce the tension-force per unit of medium (9) width at the end of an alignment zone compared to the tension force per unit of medium (9) width downstream as exerted by the drive system (7, 8) of the printing system by a factor of at least 3.

3) The device of claim 1 or 2, wherein a finite second web movement trajectory (Lguided) satisfies the relationship Lguided > max (50mm, mediumwidth/4).

4) The device of any previous claim, wherein the nearly tension free loop has a tension of 2×10^{-2} N/m per gram per square meter of web material or less.

5) The device (1) of any previous claim wherein said entry position defining means (2) comprises one or more friction inducing rollers or fixed shaft that increase the paper tension in the alignment section above a minimum tension of 6 N/m.

6) The device (1) of any previous claim wherein the means for defining the curved or partially curved first movement trajectory comprises one or more fixed rollers or curved shells (3, 3', 3a, 3b 3c) that contact the web over at least part of its width and wherein at least one of these fixed rollers or fixed shells has a radius of curvature exceeding 32 mm.

7) The device (1) of any previous claim, wherein the lateral guiding means comprises adjustable parallel flanges (4', 5') adjustable in a lateral direction with respect to the web (9).

8) The device (1) of any one of the claims 1 to 5, wherein the means for defining the curved or partially curved first movement trajectory comprises one or more curved shells or fixed rollers (3, 3', 3a, 3b 3c) that contact the web (9) over at least part of its width and wherein the lateral guiding means (4, 4', 5, 5') comprise adjustable parallel flanges adjustable in the lateral direction with respect to the web (9) and wherein tubular extensions (4', 5') comprising end segments of said fixed rollers or curved shells (3, 3',

3a, 3b 3c) are integrated with said adjustable flanges (4', 5') and are moveable with those.

9) The device (1) of any of claims 6 to 8, further comprising additional flexing means (11) that prevent wrinkles being formed in the web when in said alignment device.

10) The device (1) of any previous claim wherein the means for defining the curved or partially curved first movement trajectory comprises a combination of at least two curved shells (3a, 3b, 3c), relatively rotatable one to the other, whose length is determined by relative rotation between the at least two curved shells (3a, 3b, 3c).

11) The device (1) of claim 10, wherein an edge of one of the curved shells (3a, 3b, 3c) is in helical form and matches the form of an edge of another of the curved shells (3a, 3b, 3c).

12) The device (1) of any previous claim wherein, wherein said finite second web movement trajectory (Lguided) satisfies the relationship Lguided > max (50mm, mediumwidth/4).

13) A method to align a web (9) of continuous print medium originating from an upstream device to a stable lateral position with respect to a printing system for further printing on said continuous web (9), said printing system comprising a drive system (7, 8), the method comprising:

guiding a print medium at a reduced tension of said print medium compared to the downstream tension imposed by a drive (7, 8) of the printing system, such that the print medium forms a nearly tension free loop prior to entering into sliding contact in a sliding zone along a means defining a curved or partially curved first web movement trajectory in the web travel direction, the sliding zone of the curved or partially curved first web movement trajectory extending over a finite length L1 satisfying the relation

$$L1 > \max(50 \text{ mm}, P/4)$$

where P corresponds to the width of the print medium,

centering said print medium by guiding both lateral edges in the lateral direction by adjustable lateral guiding means (4, 4', 5, 5') along a finite second web movement trajectory that comprises at least a part of the first trajectory where the print medium is in

friction sliding contact with said means defining said curved or partially curved trajectory, L2 being the length of simultaneous side-guiding and support for sliding length (L2) of the second trajectory satisfying the relationship: $L2 > 2/3 * \max(50\ \text{mm}, P/4)$.

14) The method of claim 13, wherein the nearly tension free loop generates a tension of 2×10^{-2} N/m per gram per square meter of web material or less.

15) The method of any one of the claims 13or 14 characterized in that said side-guides (4, 4', 5, 5') are adjusted to a distance W satisfying a relation compared to the print medium width P

$$P - 2\ \text{mm} < W < P$$

16) The method of any one of the claims 13 or 14 characterized in that said side-guides (4, 4', 5, 5') are adjusted to a distance W satisfying a relation compared to the print medium width P

$$P - 1\ \text{mm} < W < P.$$

17) The method of any one of the claims 13 to 16, wherein said finite second web movement trajectory (Lguided) satisfies the relationship Lguided > max (50mm; mediumwidth/4).

18) The method of any one of the claims 13 to 17, wherein braking means (6) reduces the tension-force per unit of medium (9) width at the end of an alignment zone compared to the tension force per unit of medium (9) width downstream as exerted by the drive system (7, 8) of the printing system by a factor of at least 3.